A CONCEPTUAL CAPSTONE DESIGN COURSE MODEL: APPLICATION TO FINAL YEAR ENGINEERING STUDENTS

F. Tarlochan[a,b], M. H. Hasan[a], L. M. Sidek[a,b]
[a] College of Engineering, Universiti Tenaga Nasional (UNITEN), 43009 Kajang, Selangor, Malaysia
[b] Engineering Education Technical Division, Institute of Engineers Malaysia (IEM),
Email: faristarlochan@gmail.com

ABSTRACT

The relationship between industry and university is very important as graduating students deal with the transition between university and the workplace. Preparing of students in the university environment for this transition can have an enormous impact in terms of their effectiveness in their first few years in the industry. Being able to understand and meeting the expectations of an industry employer at an early stage is advantageous for both sides. A greater level of productivity is expected from the employee and the employee is able to practice engineering with a much greater level of confidence and competence. The capstone design course is potentially a very effective way to create the bridge between academia and industry. Engineering design has received increased attention in United States engineering curricula as a tool for making engineering more attractive to students while also developing many of the practical skills needed for engineering practice. Design is considered by many to be the distinguishing feature of engineering and the motivating factor in the learning of engineering. Capstone design courses are also an avenue for developing many of the higher-level engineering learning outcomes and those requiring integration of knowledge. The objective of the paper is to present a conceptual model for a capstone design course that could be of used in countries that would like to embark on integrating capstone courses into their curriculum.

INTRODUCTION

Industries looking for engineers have growing hopes as to how well prepared engineering students ought to be when embarking on engineering practice. Any previous experience such as through industrial trainings is highly valued as it means that the student has potentially been exposed to some real life engineering. Fresh engineers entering the workforce may be expected to handle many aspects of engineering and to begin making meaningful contributions as soon as possible in the implementation of projects. Here, engineering capstone design course can present engineering students with a culminating design experience on an applied engineering project [1, 2, 3]. Within the capstone engineering design projects, we can attempt to incorporate as many aspects concerning engineering practice as we believe are necessary. The course can be used in equipping students with a carefully selected knowledge set that covers most of the topics and issues which an engineer may be expected to face when practicing engineering. For an example, the course could include issues ranging from ethics and product liability to project scheduling and designing for worldwide markets. Collectively these topics or modules incorporated in the course provide students with thinking skills and knowledge that help them quickly become effective and competent engineers.

COURSE OBJECTIVE AND DESCRIPTION

The objective of the capstone design course should be focused and specific. The suggested objective is as follows:

> To design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, ethical, safety, manufacturability, and sustainability.

The objective should be realized through industry-linked capstone design projects which are open ended design projects that employ principles of machine design, engineering analysis and well-designed engineering systems. As much as possible the projects should be proposed by industry partners. Once projects are finalized, design teams are formed, students work on the design process to come up with a liable and viable solution. In most cases a prototype is built and tested or existing equipment is modified and tested. Emphasis is placed on soft skills such as communication skills, technical writing, and regular communication with partners from the

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industry. Student teams operate in a team-based industrial environment with “real-life” industrial projects. It should be noted here that in a capstone design course, as the students go deeper and deeper into the project, the emphasis should be on skills development rather than knowledge as the students have been provided with most of the required engineering fundamentals in their early years of the engineering program. The development of skills can be broken down into three as shown in Figure 1.

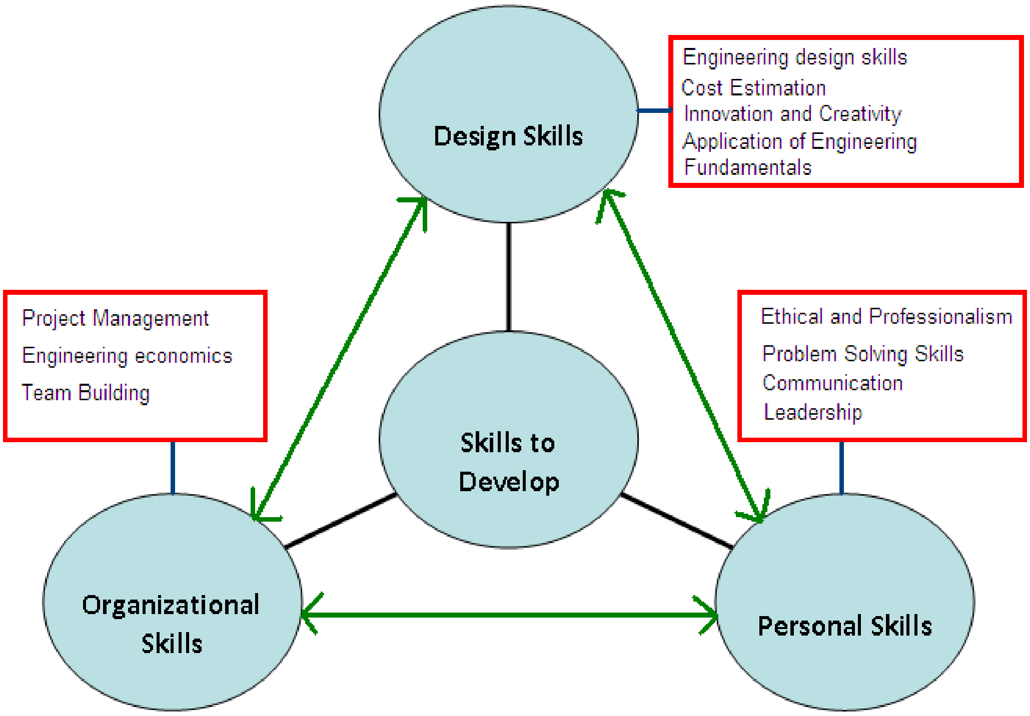

Figure 1: Development of skills through capstone design projects

In the context of executing the project, the students will have to follow a sequence of phases. This sequence of phases or processes can be explained using Figure 2. Nonetheless, due to time constraint, being a one semester course in nature, the focus for the student could be only until item 5 of the product life cycle shown in Figure 2.

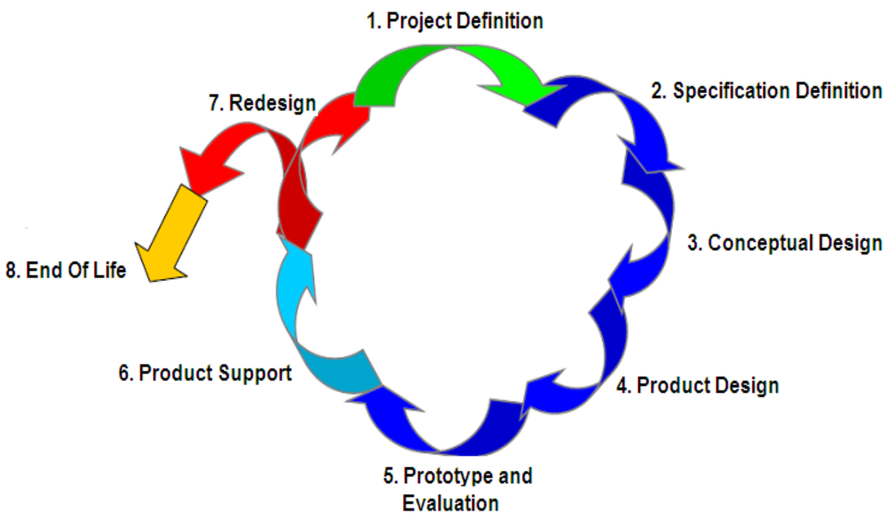

Figure 2: Complete product life cycle

1. *<u>Project Definition:</u>*
   The objective of the project definition stage is to better comprehend the need of the project and begin to translate the statement of need into specific and measurable requirements that will guide the design

process. This will also include planning for resources such as time, funding and equipments. Student teams will be encouraged to work closely with their industrial partners.

2. *Specification Definition Phase:*

   Students will be required to complete all necessary tasks from the project definition stage before continuing with the specification definition stage. The main purpose of the specifications phase is to convert the voice of the customer, which is fuzzy and unquantifiable, into engineering specifications, which are measurable. There will be two major tasks in this stage, the development of the customer specifications, and the development of the engineering specifications. The design specifications or engineering specifications are a means to measure the customers' requirements.

3. *Concept Design Phase:*

   Design teams will need to have completed all necessary tasks from the project specification stage before proceeding to the concept development and evaluations stages. This phase focuses on generating potential solutions and evaluating them. Once a number of possible solutions are generated, students will need to create a decision matrix (Pugh Matrix) to help choose between the diverse alternatives. A decision matrix is a systematic way to evaluate the possible alternatives in addressing the customer specifications. At this point, it may be important for the design team to meet the industrial partner in order to get their input on the decision matrix.

4. *Product Design Phase:*

   The objectives of this phase is to use the information from the earlier three phases along with engineering and science fundamentals to develop a product or process or solution. Input and data from the industrial partner will be crucial in determining the success of this phase.

5. *Prototype Development and Evaluation Phase:*

   In this phase, the design teams along with the help from the industry partners should build and evaluate a prototype, based on the outcomes of the four initial phases. It is also in this phase that the students will learn to do troubleshooting on their design. The success of this phase depends on two main factors, time and funding. Students should have efficient time and project management skills, whilst the industrial partner should be willing to fund the building of the prototype.

ASSESSMENT AND TIME FRAMEWORK

For the development of the assessments framework for capstone design courses, the fundamental assessment should comprise of two major areas, which are *student development* and *solution development*. Under the *student development*, the emphasis is on two performance areas: student capacity and team capacity. For the *solution development* the performance areas should be solution acquirement; on whether the specifications reflected in-depth understanding of the customer needs, marketing issues, technology readiness, and societal concerns about the solution, and provide clear targets for development of a feasible solution. The other performance is the overall solution itself which looks at the final product or the outcome of the project. The framework can be summarized in Figure 3 and Figure 4 suggests the appropriate time frame. Since this course is labor intense, it is recommended to be a four or the least a three credit hour course.

CONCLUSION

The conceptual design course model presented in this paper offers an important source for improving existing engineering curriculum to prepare our students to meet the demands and challenges in industries. The model addresses to both student development and solution development in four performance areas – student capacity, team capacity, solution acquirement, and final solutions. The model describes the use of engineering design process to achieve the performance areas. In the context of the capstone design course, this paper presents an integration of student development and product development (solution). These two main stages of development

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work in tandem and are assisted by the usage of the design process, and related to the four areas of performance desired namely; (1) student capacity, (2) team capacity, (3) solution acquirement and (4) final solution. Assessment of performance in each area may occur repeatedly during a project and should also be reflected or accounted for at the completion of the project.

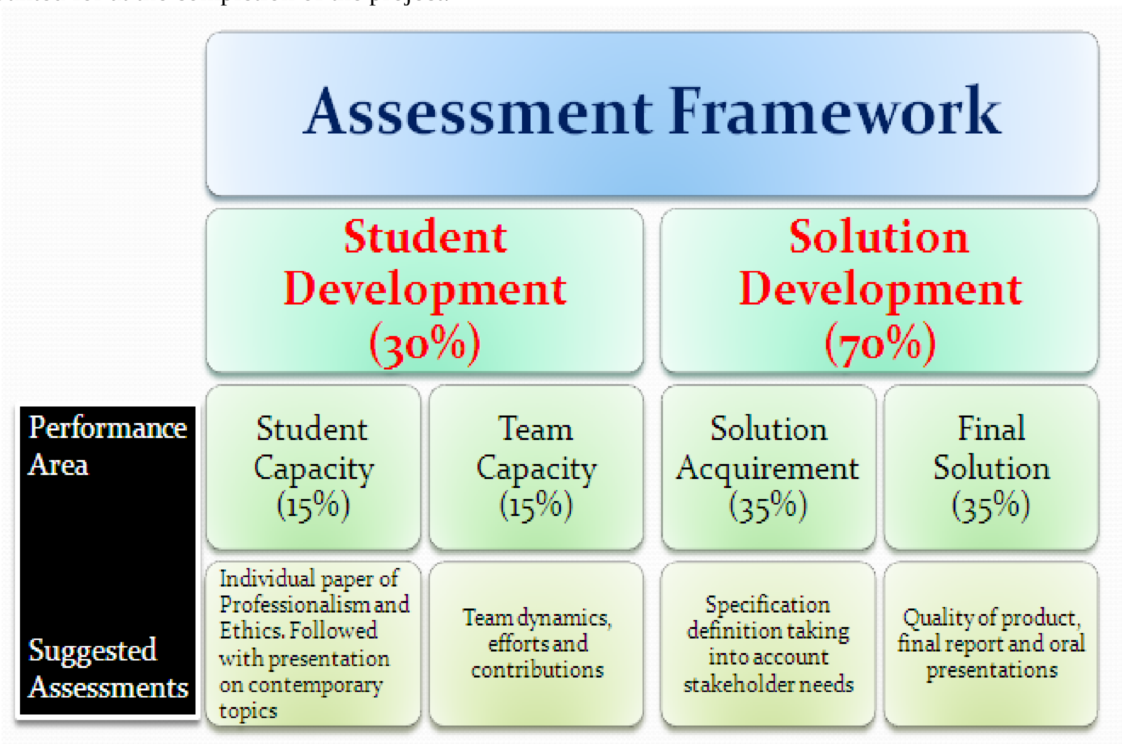

Figure 3: Proposed assessment framework for an engineering capstone design course

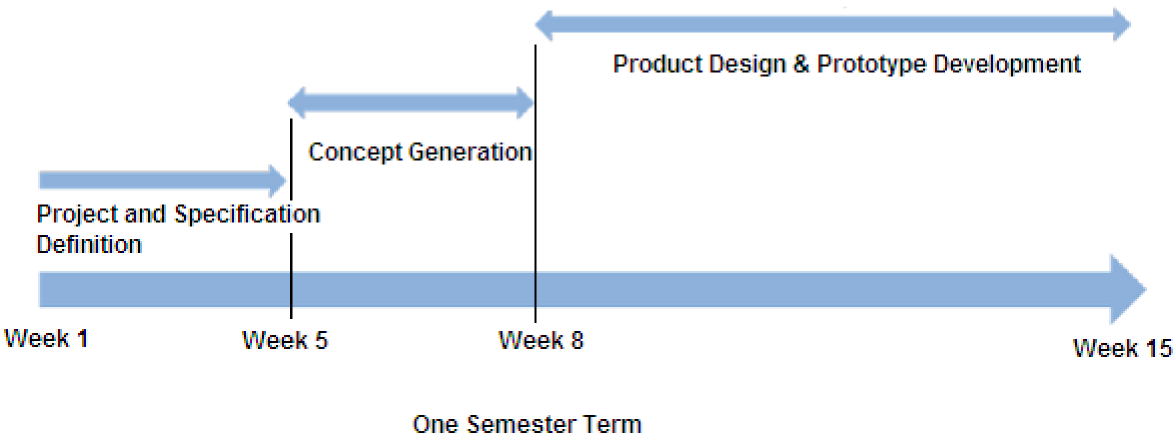

Figure 4: Proposed time framework for an engineering capstone design course

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